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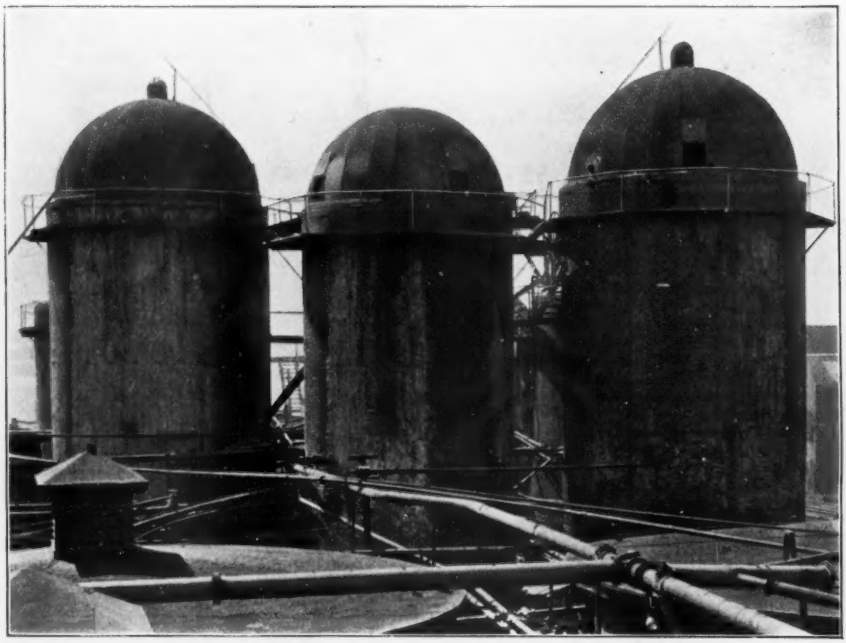

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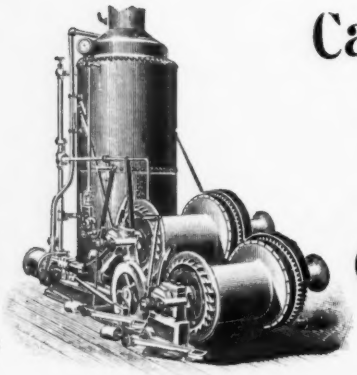

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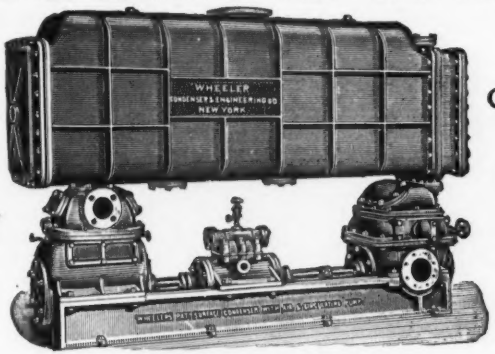

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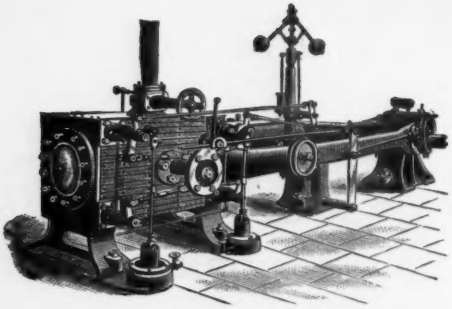

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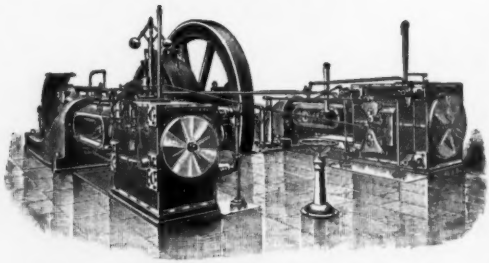

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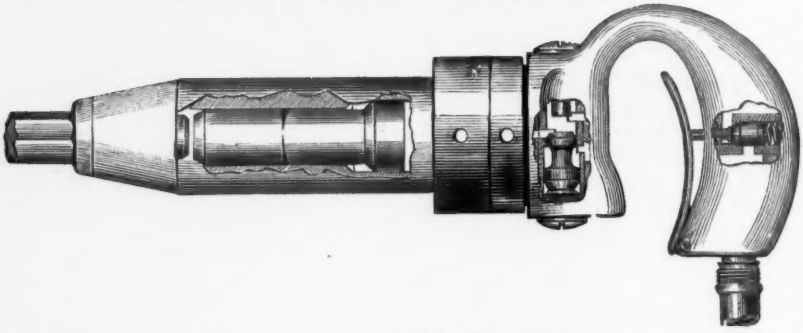

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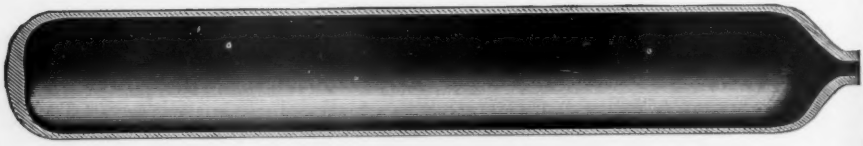

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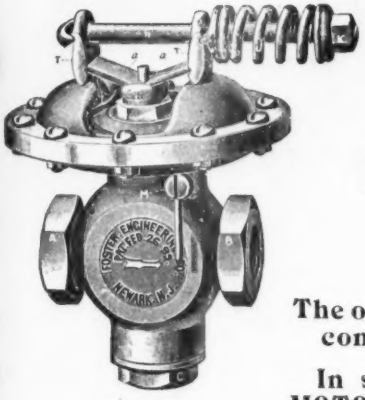

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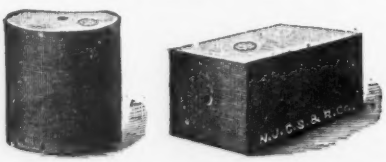

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VOL. III. APRIL, 1898. NO. 2.

Volumetric efficiency in air compressor practice is a subject which has been neglected by builders of machines and by the public generally. Catalogues of air compressors, with great unanimity, claim about 100 per cent. volumetric efficiency: In other words, the capacity of an air compressor in free air compressed is measured by the piston displacement, the theoretical volume of the cylinder being taken at a certain piston speed. It is plain that no machine however perfect will deliver as much air as this, because clearance, leakage, etc., must be taken into account. So long as makers are not required to give a guarantee, it is well enough to base figures upon the piston displacement as this gives a base line for comparison. Recent improvements in air compressors have been in the line of reduced volumetric losses. The old DuBois-François type of compressor which used water in the air cylinder for the purpose of cooling and filling the clearance spaces made slow speed necessary and the abandonment of water injection followed closely the development of improved forms of valves reducing clearance spaces to a minimum. The theoretical volumetric efficiency of an air compressor is also reduced in actual practice because it is not possible to fill the cylinder at atmospheric pressure except perhaps at very slow speeds. Any light indicator spring will show from one to three pounds vacuum in an air cylinder when used at its normal piston speed. The higher the speed, the greater this vacuum will be. A partial vacuum is necessary in any case to get the air in the cylinder, even with a perfectly free mechanically moved inlet valve of large area. In compound compressors the pressure line in the initial cylinder usually shows a partial vacuum greater in proportion as the cylinder is larger and usually more noticeable than in the ordinary indicator card because of the use of the light spring. Actual volumetric efficiencies vary from 85 per cent. in small poppet valve compressors to 97 per cent with long stroke Corliss machines. In the latter this high efficiency cannot be maintained at a piston speed of over 350 feet per minute. 97% volumetric efficiency is obtained in high class Corliss compressors of the best type. The usual straight line or pony type of compressor which is designed to run at high speed does not give a high volumetric efficiency, because of the inertia of the discharge valves which does not permit them to seat quick enough to prevent some of the compressed air from getting back into the cylinder on the return stroke. This type of machine furnished by makers of first-class air compressors working under the normal conditions will give about 90 per cent. volumetric efficiency. A compressor of this type with an air cylinder say 20" in diameter by 24" stroke, and which has a rated piston speed of 375 feet per minute, if run at only 250 feet per minute, will show a volumetric efficiency of 95 per cent. and this will be reduced in proportion as the speed is increased. These figures are based on perfectly tight valves and piston, a condition which should exist in machines of the first class when in the hands of good engineers.

Compressed Air on the Holland Torpedo Boat.

A study of the John P. Holland Torpedo Boat Co.'s latest type of submarine boat convinces the student of naval architecture that she is light of draught, seaworthy as a cork, handy as a toy, and able to dive into the depths of the sea like a mackerel, and that from the standpoint of mobility and power of attack she is better than a battle ship and a torpedo boat moved in unison for attack upon a port or a fleet. The modern battle ship is a massive, floating ortress, embodying the ideas of military engineers, and the traditions of the naval constructors of Great Britain and France, who superimposed the Ericsson turret principles upon the broadside man-of-war of forty years ago. The torpedo boat of the best existing type is merely an evolution from the bomb boats and powder ketches of fifty years ago, whereas the Holland submarine boat is constructed in strict accordance with the latest improved ideas and inventions, all of which are combined to make her swift to execute the end for which she has been contrived.

The science of submarine boat construction germinated when David Bushnell, of Saybrook, Conn., in 1777, invented and built a craft which because of its shape he named, the Tortoise. In a letter to Thomas Jefferson, he stated that the craft was made habitable under water for twenty minutes, by the use of air pumped into two small copper cylinders, these cylinders were fitted with crude stop cocks, and placed as nearly as possible to the nose of the sole occupant of the craft, who navigated it by means of an oar. But one attempt to use the craft was made, and that turned out badly for the navigator and inventor.

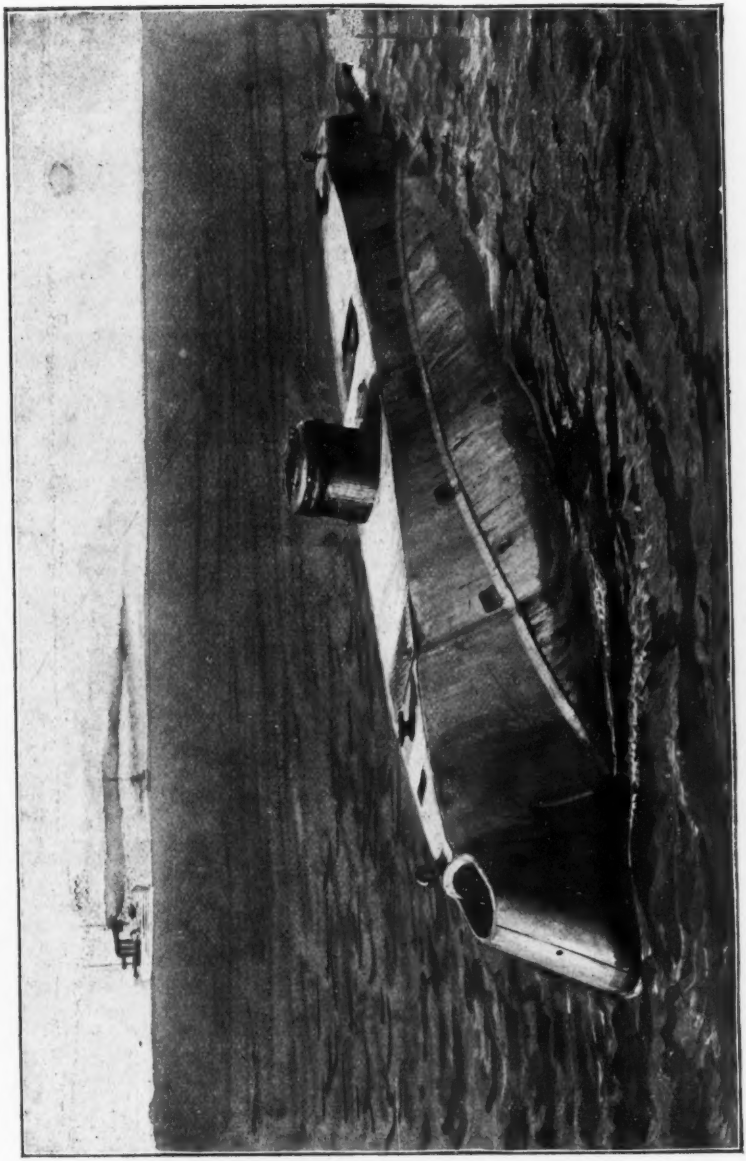
Bushnell afterward made an improved submarine boat, which met with public derision, but many years afterward his grandson, C. S. Bushnell, of New Haven, Conn., adopted several of his grandsires' ideas in a submarine boat which he and John Ericsson built and offered to the government. It was rejected, then Ericsson began work on plans for a monitor type ship, and Bushnell by the force of his energy, induced the Navy Department, which was bitterly prejudiced against Ericsson, to accepte the Monitor, subject to tests in battle at the expense of Bushnell and others, who furnished the capital that built and equipped her.

Great was the surprise of the doubting Thomases of the navies of the world, when a terrible conflict thrust itself on the wooden fleet in Hampton Roads, and in the heat of battle with the Confederate knife aimed at her heart, Columbia saw by the light of three ships burned by the Merrimac, the Monitor, despised and rejected by nearly every navy, steam into the broad bay to achieve a glorious victory, save the capital of the nation from capture, and sound the death knell of wooden navies.

Because the science of constructing compressed air apparatus was in a crude state in the days of the Civil War, Ericsson and Bushnell, were unable to accomplish satisfactory result in submarine craft, and for lack of compressed air apparatus, the ships of the monitor type were almost uninhabitable. So naval science stopped short until in due season the advance of compressed air science by leaps and bounds gave naval architects a fulcrum on which to place a bar to lift a world of progressive ideas into perfect shape. The great defect of the monitor type was their crude system of ventilation that failed utterly at sea or in harbor; the excessive heat generated by the boilers, the rotting of the wood work, and the galvanic action set up by the action of bilge water upon copper and iron fittings formed such a pest house as to render them more dangerous to life than the shot and shell of the enemy.

Jefferson Davis in his account of the Civil War, states that submarine torpedo boats were the constant theme on the tongues and pens of the Confederate torpedo division, who sank fifty-eight Federal vessels and kept the blockading squadrons out of Charleston, Savannah, Wilmington and Mobile for several years by the use of torpedoes. Several sorts of submarine boats were built by these officers, but all failed to meet expectations; one was sent out from Charleston to attempt the blowing up of Commodore Goldsborough's fleet; but she was never heard of after setting out and diving beneath the surface. It was supposed by the Confederates, that the crude system of supplying air failed, or that the pressure of the sea burst in the sides of the boat and drowned the dozen men aboard.

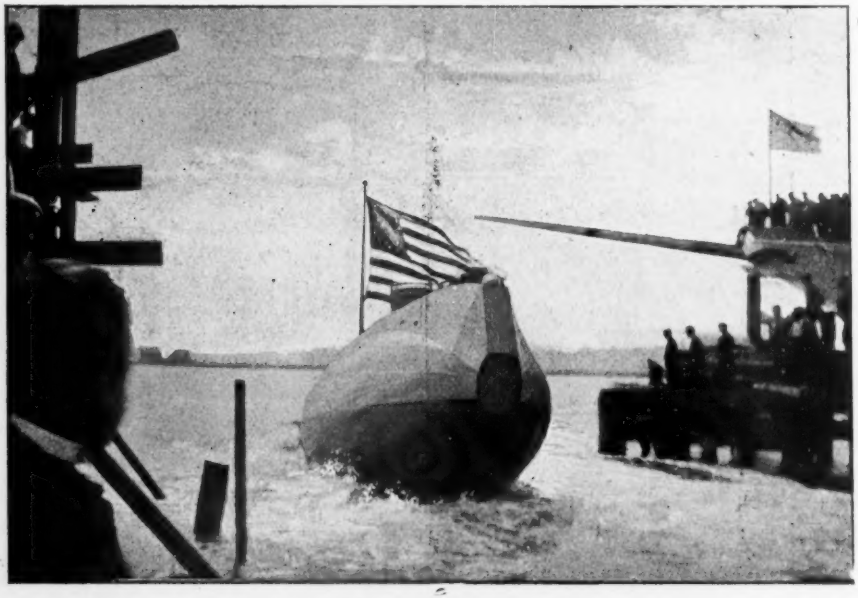
That was the last attempt at submarine work until more than twenty years ago, when Mr. John P. Holland, began a series of experiments with boats of his own in-



THE HOLLAND TORPEDO BOAT.

vention. These experiments have been continued by him from that day to this and have resulted in the boat now maneuvered by him in New York bay. The principles of construction are adapted for any required size and armament according to the requirements of purchasers. The existing boat tends to resemble nothing so much as a Salisbury dory inverted upon a Nantucket whale boat. She is 53 feet long, eleven wide amidships, and of seventy-five tons displacement. The hull is made of steel plates, rivetted to a steel skeleton frame. Amidship is a conning tower so made as to extend from two to three feet high, or telescope flush with the hull. Within the hull, immediately below the conning tower, are the two rudders, one for surface sailing, the other to regulate the depth at which the boat is operated when submerged, and the speaking tubes. electric bells, and a table connected with apparatus for manipulating camera lucida, used when the boat is submerged for portraying the appearance of the surface for miles around. The view is secured by means of a steel tube thrust above the waters and fitted with camera apparatus. There are three sources of energy for propelling the boat above and below the water, ex pelling water, discharging torpedoes and dynamite guns, and lighting the ship internally and externally; these sources are compressed air, gasoline and electricity.

The most important agent is compressed air, without which it would be impossible to operate the boat five minutes under the sea. The air compressor which breathes the breath of life into the craft, is an Ingersoll-Sergeant Drill Co.'s single acting compressor, belt driven from a gasoline engine, when the boat is on the surface, and from an electric motor switched to a storage battery, when the boat is submerged. The compressor is capable of compressing air to 2,500 pounds pressure; the diameter of the low pressure cylinder is 6 inches, the high pressure cylinder is 1¾-inch. diameter, with 8-inch stroke. Both cylinders are immersed in a water box, which cools the air during compression. Solid discs serve for fly wheels. The space occupied is only six feet and five inches long, and two feet high. The highest value of the compressed air is for the respiration of the crew, numbering ten men. For this purpose the air is expanded through two reducing and one regulating



HOLLAND BOAT DIVING.

valve, and is set free at the normal atmospheric pressure.

Six times the requisite volume of air is available; the surplus air is used for counteracting the deleterious effects of the ventilating pumps, which would produce a near approach to a vacuum, if the air supply from the tanks was interrupted in its even flow. The steering and diving gear are operated by compressed air, which also maintains the air pressure throughout the boat to equalize the pressure of the sea when the boat is submerged. The boat is quickly submerged by admitting sea water to a series of steel tanks connected with the compressed air system. A dive of forty feet below the surface is made with safety and comfort in a minute. When the commander signals to elevate the boat from the depths, air is forced into the water tanks under high pressure, and as the water is expelled the boat rises swiftly to the surface. The air tanks have been tested to stand a pressure of 3,000 pounds to the square inch, and are calculated to hold out for a submergence lasting ten hours, but if the supply should fail after nine or ten hours, the tanks can be replenished by means of a tube projected to the surface as a suction pipe.

The armament of the boat consists of one dynamite gun, one automobile torpedo tube, and one aerial torpedo tube. These tubes and gun are made terrible engines of propulsion of projectiles by the power of compressed air, which not only enables the torpedo and gun operators to hurl torpedoes and great masses of dynamite with deadly precision and irresistible force, but immediately restores to the boat the weight of 800 to 1,000 pounds lost when a projectile or mass of dynamite is discharged. The muzzle energy of the dynamite gun is 750 tons, a force powerful enough to crash through the bottom or below the water line of the mightiest battle ship afloat, and send her hurtling to the bottom of the sea in the twinkling of an eye.

Like nearly all valuable inventions in the domain of naval science, the Holland boat represents a series of long continued experiments conducted by civilians contending with numerous difficulties, and she is an embodiment of the belief of the most advanced naval architects, that from the latest achievement in submarine engineering, the battle ships and cruisers are at the mercy of the submarine boat that lurks beneath the sea, noiseless, and as swift to strike deadly blows as the sword fish which steals under the mighty carcase of the whale, and with one lightning like thrust of its sword reddens the sea with the blood of the mightiest monster of the deep, which with the churning of the waters, and a flip of its flukes, rears upward for a brief second and then plunges down to the uttermost depths of the sea lifeless and inert.

Ere long the Holland boat may be tested in battle here or beyond seas, for war looms across the track that the ship of the world's progress is coursing; who can tell what lies in its bosom? But there is a sound heard from that direction which tells us it will not be the unarmed or the weak nation that will fare best when the thunder bolts crash from the war clouds.

War has endured through thirty centuries recorded by history unchanged or unchangeable; it rests as solid as the bottom of the sea, uninfluenced by the motion of the waves of time. Pugnacity and warlike tastes are as strong in the masses of mankind to-day as at any time in history, and the predominant spirit of several highly civilized nations is the policy of war, victory and domination.

G. WILFRED PEARCE.

Compressed Air Substituted for Steam.

A recent instance of the economy resulting in certain cases, from the substitution of compressed air for steam is found in the Paraffine and Lubricating Department of the extensive refining plant of the Tide Water Oil Company at Bayonne, New Jersey. In this plant the air from the compressor goes to a suitable tank or reservoir, thence to a series of direct acting steam pumps first reheated as shown in fig. 1—thence through second reheater to second series of pumps, which were formerly actuated by steam, the exhaust air being finally utilized in the bleachers. The equipment not only performs the essential work formerly done by steam, but the compressed air system also does away with the use of several small compressors which supplied air to two pressing plants, the wax refinery and also to the acid works. The machinery was furnished by the Ingersoll-Sergeant Drill Company, of 26 Cortlandt Street, New York, and Mr. P. R. Gray, Superintendent,

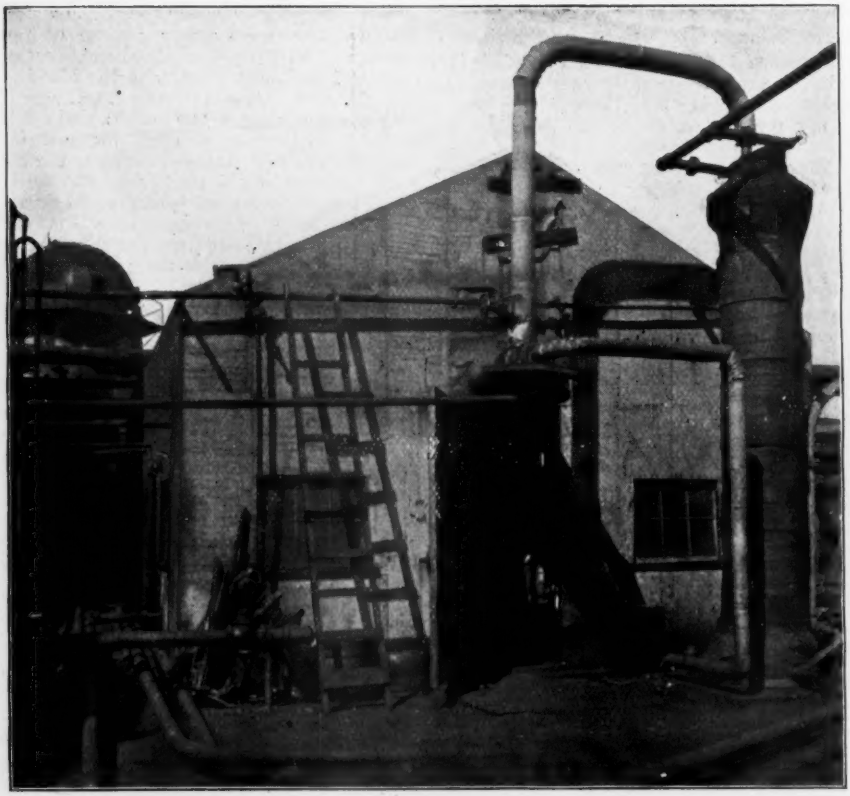


FIG. 1.—REHEATING AT PUMPS.

of the oil works designed and put in the system.

From the compressor the air is conducted into an old steam drum which was formerly attached to the No. 2 battery of boilers, and from this drum, which serves as an air storage tank, the main line leads to the agitator, Fig. 5, shown on cover, with branches at several intermediate points for supplying the pumps with air, where steam was used heretofore. Heaters for reheating the air for power were arranged in connection with the pumps, and the piping was so placed that the air after being twice used as power was finally used, as stated, for clearing the oil in the bleachers. The large pipe and fittings formerly employed for blowing the agitators were all replaced by smaller sizes in more simple arrangement. The larger portion of the air is used in blowing the agitators for which purpose three large steam blowing engines were used before.

One portion of the pumping plant is illustrated in Fig. 2. These pumps are of the Smith Vaile duplex type, and are arranged in two groups in the same compartment. The total number of pumps is 14, 12 of which are placed in the building shown in Fig. 1. Six of these have steam cylinders 7 inches in diameter, pump cylinders 6 inches in diameter by a stroke of 9 inches; one pump having steam cylinder 12 inches,

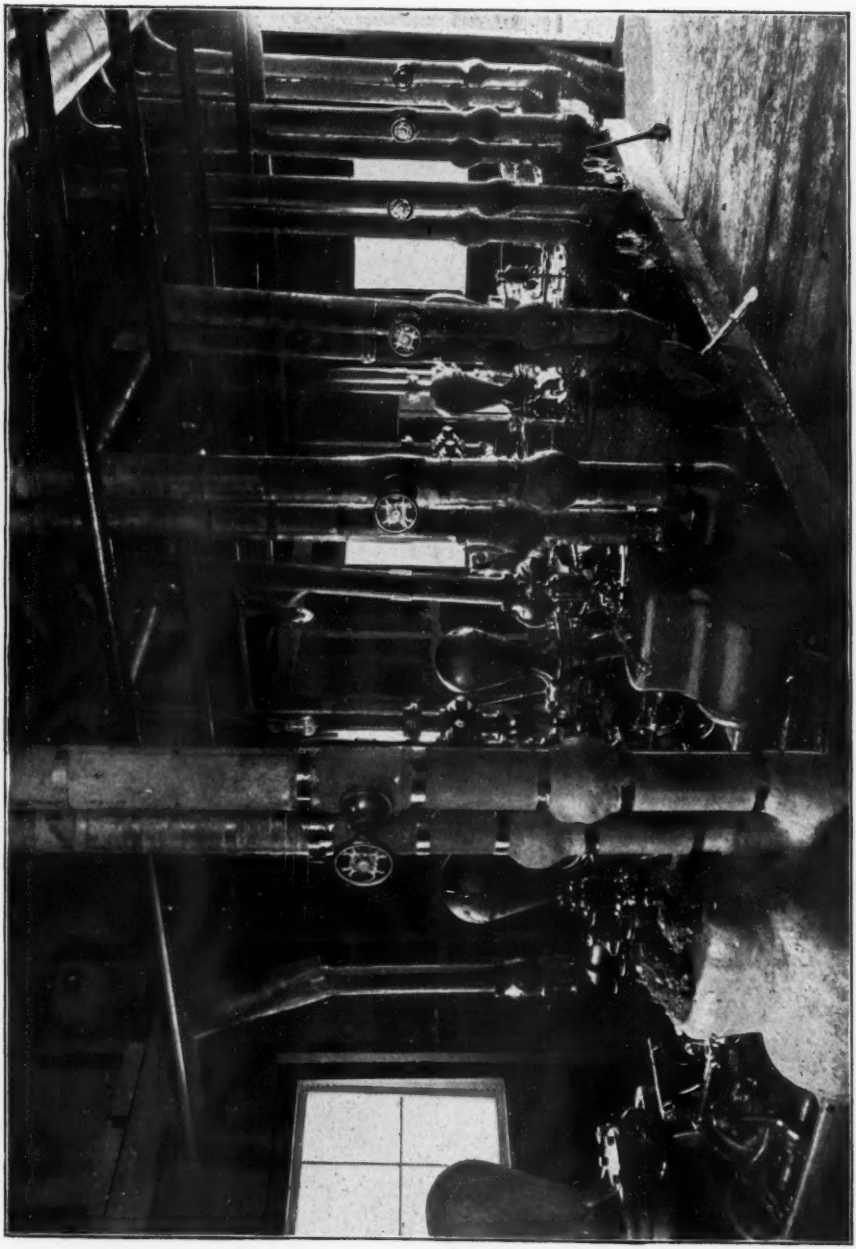


FIG. 2.—ONE SERIES OF PUMPS.

FIG. 4.—REHEATING FOR ACID WORKS AND PRESSING PLANTS.

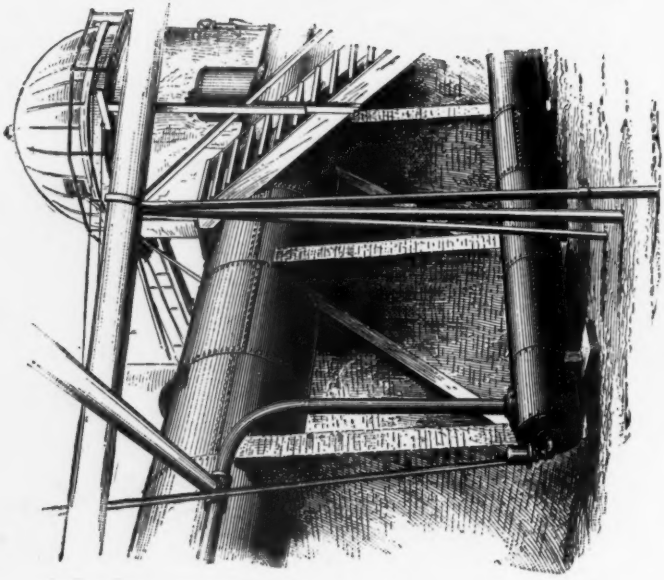


FIG. 3.—STORAGE TANK.

pump cylinder 6 inches by a stroke of 11 inches; four pumps, steam cylinder 5 inches, pump cylinder 4 inches, and a stroke of 8 inches; and one pump, steam cylinder 6 inches, pump cylinder 6 inches by 6-inch stroke. Air for the first series of pumps is first reheated in the reheater shown in Fig. 1, the air being used at a pressure of 60 pounds, and exhausted against a back pressure of 30 pounds. The exhaust is again reheated and passed to the second series of pumps which are designed for lighter service where it is exhausted against a pressure of 7 pounds into a storage drum, Fig. 3, from which it passes to the bleechers. This third use of the air was not included in the scheme as at first mapped out. The system is so adjusted that if the work being done at any time by the light service pumps does not use all the exhaust air from the high pressure pumps the surplus may be passed to the agitators for blowing.

In a statement made by Mr. Gray to the directors, we find the following: "This plant has displaced three steam blowers which used, when running in aggregate, at the rate of 239 horse power of steam, average time run eight hours in 24, or net average, 79 boiler horse power. Also two air compressors, 34 horse power; also steam displaced in 14 pumps which before used every 24 hours 90 boiler horse power, making total boiler horse power of steam displaced by air at the agitators, 203. Add three smaller compressors at the pressing plant and wax refinery, using an aggregate 30 horse power, makes a total of 233 horse power. Deduct from this the average of 55 horse power used by the Payne engine to drive the compressor makes a saving of 178 boiler horse power or $4,450 per year."

The plant was started in January 28, 1897, and with a few exceptions has been in use ever since, has run without a hitch or drawback, and does all that was expected of it by the company.

Experiments with Liquefied Air.

Our readers have been very much interested in liquefied air, its production and utility, and we have frequent inquiries for information on this subject. This is no wonder for the matter is full of mystery in every phase. Little of a practical nature has thus far been developed except that which has been accomplished by Mr. Charles E Tripler, of New York, and a few other experimenters. What we know of it is that it can now be produced in practically unlimited quantities' but the cost has not yet been disclosed.

Mr. Tripler uses a three-stage air compressor of the Norwalk type. Air is compressed to 60 pounds, then to 400 pounds and finally to 2000 pounds to the square inch. It requires 50 to 60 horse power to do this, and during compression the air is cooled by an intercooler of jacketed pipes.

When the air is compressed to 2000 pounds it migrates through an apparatus that produces liquefaction. After about fifteen minutes liquefied air can be drawn from a tube like soda from a fountain, but not with such a pressure. The liquid is colorless, and cold down to—312 degrees.

Prof. Tripler places this liquid air in glass jars uncovered and packs it in a tin can, surrounding it with felt. It can be kept for a long time. A trip to Washington or Boston scarcely diminishes its volume.

On March 16th, Prof. Tripler delivered a lecture at Franklin Institute, Philadelphia, in which he made several experiments with liquid air, which he had brought with him from his laboratory in New York.

A dipperful taken from the can boils violently and drops are fiercely sent upward; it then simmers down and is quite gentle and contains solid particles of carbonic acid and possibly ice. If the liquid is poured on a piece of ice, it bounds off like water from a hot stove. If you dip your finger in the liquid no serious cold occurs, but the heat of the hand evaporates the liquid very quickly and a coating of vapor on the finger follows.

If a piece of tin be placed in the liquid and left there until it cools, the effect produced is that it may be broken in pieces like glass.

Other metals, such as copper and platinum, remain tough after the same process. The strength of iron would be increased by this cooling.

The magnetic character of liquid oxygen can be exhibited on a large scale in the

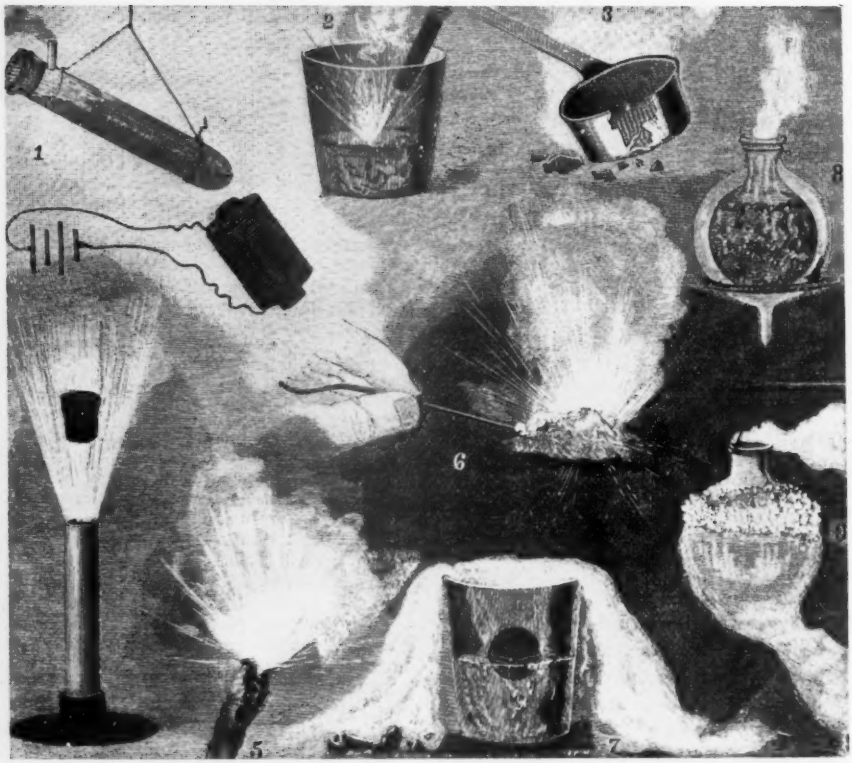


FIG. 1.

manner shown in Fig. 1. A test tube with a side tube is filled with liquid oxygen, and a cork inserted. The side tube allows free evaporation to take place. This is then suspended, as shown, by a sling. If an electromagnet be brought near the end of the tnbe, the tube swings toward and adheres to the pole of the magnet just as if it were a piece of iron.

Fig. 2 shows the mode of ignating a steel pen or watch spring in the liquid oxygen. It is only necessary to stick the point of the steel into a match and light it, to furnish a sufficient heat to communicate the fire to the steel when it burns with the same brilliancy as in the ordinary experiment.

Fig. 5 shows a most beautiful experiment in which a newspaper crumpled into a roll has been saturated with liquid air, and is set on fire at one end. It burns with violence, but not so rapidly as in the liquid oxygen.

Of course matches will be relighted, a piece of paper take fire or a cigarrette burn if a spark remains in any of these, upon exposing them to the oxygen in the glass of liquid oxygen.

Fig. 6.—All the experiments usually performed in illustrating combustion in oxygen may be performed with heightened effect by means of richly oxygen liquid air. A piece of cotton waste saturated with the liquid oxygen, when touched by a taper from a safe distance, it burns with explosive violence in a manner similar to gun cotton.

Fig. 7 shows a dish of liquid air in which a rubber ball is floating. The vapor flows over the edge of the dish but does not rise in a cloud from it the same as steam would, since it is much heavier than gaseous air at ordinary pressures When the rubber ball has been cooled to the temperature of the liquid it becomes exceedingly brittle and if thrown against the wall it would break into

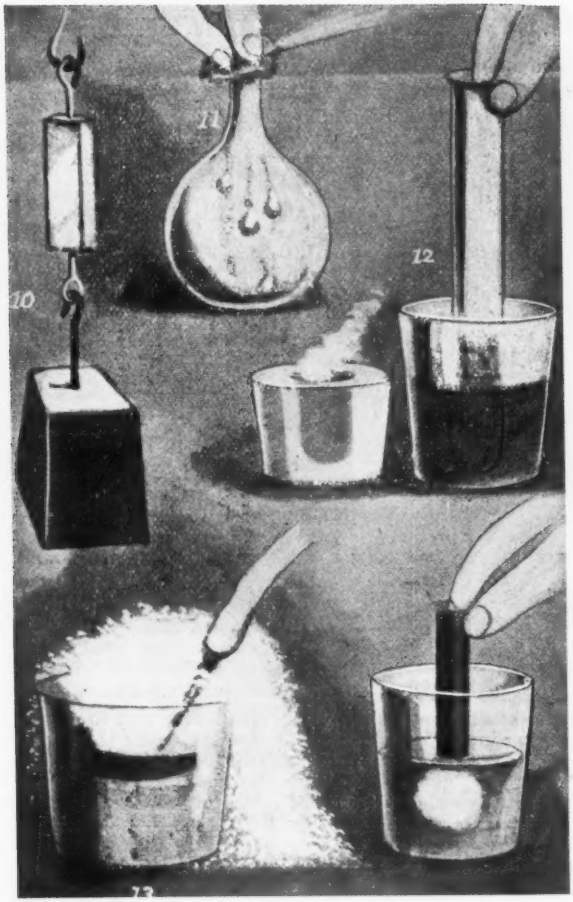
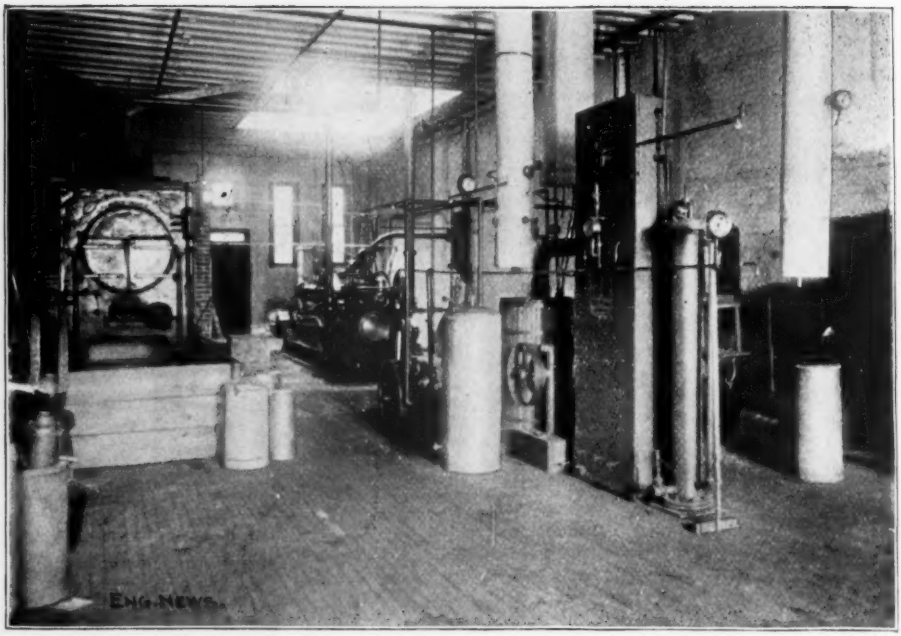


FIG. 2.

many pieces. A billiard ball by cooling in the same way when exposed to an arc light for a few seconds shines with a brilliant green phosphorescence.

Whiskey and alcohol are frozen by means of this liquid.

A most striking experiment has been designed to show the tensile strength of frozen mercury. Fig. 10 illustrates this. Into a paper dish is poured a quantity of mercury. Into the ends of the dish have been inserted a pair of heavy screw eyes. If this dish is placed in a basin of liquid air, the mercury is quickly converted into a solid, since its freezing point is relatively high; 39 below zero. Now this, suspended in the manner shown, will support a heavy weight for a long time. A block an inch square in cross section will not melt under 20 to 30 minutes. Of course, anything else could be done with the frozen mercury which might be done with any other similar piece of metal; as, for example, it might be used to drive a nail. If put into a kettle in the atmosphere it will boil vigorously, and the vessel soon becomes covered with frost. Then if a tumbler of water is poured into it it gives forth a greater power than



LABORATORY OF MR. CHAS. E TRIPLER, NEW YORK.

when the effort is made by strong fire heat.

Fig. 11 shows a very brilliant experiment A large flask 10 or 12 inches in diameter, is filled to the neck with water. Into the top of the flask liquid air is poured. This at first floats, since the specific gravity of liquid nitrogen is 0·865; but as the nitrogen boils away, leaving the oxygen behind, the drops of oxygen begin to sink into the water, since its specific gravity is 1·124. As these drops sink, they are partially turned into vapor, which of course tends to rise through the water. This may be many times repeated, giving a very beautiful exhibition since the drops of oxygen may be as large as an inch in diameter.

Fig. 12 shows a tube in which liquid air is in a tube and the tube being inserted in a glass of whiskey which in a few minutes will become solid; on warming the outside of the glass the solid whiskey may be removed.

Fig 13 shows a jet of carbonic acid directed into a dish floating in a glass of liquid air; this is immediately frozen and becomes carbonic acid snow in the open air, which, on being placed upon a table passes into the gaseous state without melting.

A quantity of liquid air is poured into a tea kettle, and the kettle is set over a hot fire of coals; the liquid air evaporates and shoots in streams from the spout of the kettle in a straight column to the height of three to four feet. While this is going on, if a glass of water is poured into the kettle, it will be found to be frozen in a very short time; and if the kettle is removed from the fire, its under surface is found to be covered with the products of combustion water and carbon dioxide frozen solid within a couple of inches of the red hot coals.

A jet of carbonic acid directed into a dish floating in a glass of liquid air (see fig. 13) is immediately frozen and forms carbonic acid snow, in the open air, which, on being placed upon a table, passes into the gaseous state without melting. A jet of steam directed into a glass of the liquid air causes a violent evaporation of the air and condensation of the steam, so that a cloud of particles rolls away from the dish, but in a remarkable short time round hailstones of the size of peas will be found floating quietly in the liquid air. They have cooled from + 212° to — 312° Fah. in the short space of a few seconds.

The practical uses and applications of liquid air have not yet been made, but doubtless the inventive world will find a place and a use for this new power. The scientific aspects of the matter are of the highest interest. By boiling liquid air in a vacuum, the lowest degree hitherto attained has been reached, and men are brought the nearest they have ever been to the absolute zero. It would appear that, at the point reached, chemical action has well nigh ceased. Even that most active element flourine, whose chemical affinities at ordinary temperatures are uncontrollable becomes comparatively inert. It has recently been cooled in oxygen boiling in a vacuum to—210° C without solidifying. It became a liquid at —187° C. In its liquid form it had apparently no desire to attack anything excepting only substances containing hydrogen, such as turpentine and benzine. Its well known action upon glass entirely ceased. It would seem probable that men have reached in liquid air boiling in a vacuum a temperature quite comparable with that of the spaces betweeu the stars, and that we may realize in a faint degree something of the time when stars and sun have ceased to shine and grow cold.

Prof. W. C. Peckham recently gave a lecture at Adelphi College, Brooklyn, in which similar experiments to the above were illustrated. The technical and scientific press in general has given much space to this subject, articles having appeared in the "American Machinist," "Engineering News," the "Electrical Engineer," and "Scientific American" from which our illustrations are reproduced, and in many others.

A description of Prof. Tripler's plant illustrated, appears in the "Engineering News" of April 14th, which comments as follows:

"The question, 'what is the utility of liquid air, and what part can it or will it pay in the arts?' is one that cannot be answered at present: there is little doubt, however, but that when further experiments have perfected machinery for its production, and its cost is small, it may play a very important part in manufacture and medicine, as a refrigerating material, a means of storing energy, for use in surgical work, and in many other directions. At present, however, owing to its considerable cost, its uses are limited to a somewhat small field, comparable to that of aluminum a few years ago."

Practical Painting by Air.

The illustrations on the following page show the Bryce Pneumatic Painting Machine in operation painting the Pan House of the Arbuckle Bros. Sugar Refinery in Brooklyn. This building consists of ten (10) floors, each 200 by 87, and from 12 to 25 feet high, each floor having 60 brick columns, 500 feet in each, so that the average space to be painted on each floor is over 27,000 square feet or 272,812 feet in all. The ceilings are of fire proof tile arched, walls and columns of brick. The entire building is being painted by The Bryce Machine under contract with John A. Chater, 132 Nassau Street, New York. King's cold water paint is used and the covering as applied by the machines is entirely opaque and white with one coat. The machines of which there are now two in operation are worked from a Clayton air compressor on the ground floor, air being taken up by an inch hose on the outside of the building and taken through the window on to any floor on which the machines are used. The illustration shows one machine at work on one of the columns which has been left uncovered at the base. The ceilings on this floor are twelve feet to the arch and are sprayed from the floor without any scaffold by the use of a four foot nozzle other ceilings are over 14 feet. There is no return of material from the ceiling.

Painting can be done in this way on floors or ceilings at the rate of 2,250 feet an hour by actual test, though 10,000 feet is a good day's work for one man holding the nozzle.

The tank shown on wheels holds 16 gallons of paint On the left side of tank are shown the valves for injecting air and ejecting air and paint. These are in one casting which terminates in an inch pipe which is screwed into the top of the tank. Inside this pipe and connecting both with the air and paint valves of the casting is a ⅜ inch pipe extending down to within 1½ inches of bottom of tank. The single hose attached on the left of valve casting supplies air. Of the other two small hose on the right of valve casting one takes the paint and the other the air to the nozzle.

PAINTING ARBUCKLE SUGAR REFINERY BY THE BRYCE PNEUMATIC PAINT MACHINE.
The column to the left partly painted. The upper part has been sprayed with white paint. The lower part still untouched.

Building 200x87, 10 floors, ceilings 12 feet, 60 columns on each floor.

The valves represented by the small handles as shown in picture are all open. The air passing in at the left passes down the wide short pipe and pressing on the top of the paint in the tank forces it up through the small pipe and out through upper valve and hose shown on the right of casting from whence it passes to the stem of the nozzle, and into an inner tube within the outside tube of the nozzle passing out at a vent at the end of this tube where it is caught and sprayed by the air passing through the outer tube.

The air in addition to performing this duty of forcing up the paint also passes straight from the valve on the left to the lower valve on the right and thence through the hose to the stem of the nozzle where it passes through a valve into the outer tube of the nozzle catching the paint at the end of the inner tube and spraying it into a fine mist. When it is desired to stir up the paint in the tank the valve handle on the left is turned vertically up, when the air passes down the small tube in the tank stirring up the paint and mixing it thoroughly.

The nozzle consists of two tubes one within the other with an air space between fitting into a stem or handle containing openings corresponding with openings in both tubes which form the valves for regulating the flow of air and paint. These consist of openings in the outer and inner tubes so arranged that the flow of paint and of air can be regulated separately or together, or either or both shut off with one turn of the hand.

The machine illustrated has been developed with great care and ingenuity and is thoroughly well made and finished in every respect. It is the most highly developed and, with one exception, the only machine in the market at this time, and is thoroughly protected by the earliest patents.

These machines are more specially in demand for painting large surfaces and ceilings with kalsomine and cold water paints also for protective painting of large bridges and iron structures and ships with the different kinds of oil paints. They can also be used for first two coats on barns and houses. One man handling the nozzle will do the work of fron eight to ten men with the brush, with often a complete saving of scaffolding. An additional saving is in the wear of brushes.

At a late hour Mr. Chater reports that the U. S. Navy has purchased these machines for painting war ships in Dry Dock.

Improved Quarry Plant.

During the past year theWashington Slate Co. has been quietly experimenting on the practical application of compressed air as the motive power for the operation of their quarry and factory plant, and it is claimed by the manager, Mr. A. P. Berlin, who designed and built the plant and conducted the experiment, that it has proven not alone successful, but has exceeded his highest expectations.

This plant is not only a novelty because it is the only successful one of the kind in the world to-day, but also on account of the general effect noticeable in the quarries and about the works by reason of its entire absence of condensed steam and smoke. Every quarry man will understand and fully appreciate the importance of having the quarries relieved of the heavy clouds of vapor and smoke which so often hang over the opening when the outside atmosphere is heavy.

The power plant is located on the Company's private siding connected with a branch of the Lehigh Valley Railroad and consists of one Return Tubular Boiler of 140 horse power, with a return draft and a nest of two reserved boilers of 90-horse power so connected with the main boiler and the machinery that either one or both can be used in running the plant.

The Air Compressor is an Ingersoll-Sergeant, Straight Line, Class "A" machine, with piston inlet valves and automatic unloading device and all the latest improvements. The steam cylinder is 18 inches in diameter and 24-inch stroke, and the air cylinder 20¼ inches in diameter and 24-inch stroke, capable of developing 127 horse power with 90 revolutions per minute and 60 lbs. air pressure. Total weight of compressor, 20,400 lbs.

The plant has all the necessary side equipments, consisting of air receivers, water tank, feed and supply pumps and a unique system of pipe and valve connections by which the steam direct from the boilers can be substituted for the compressed air and the compressor put out of service in case of emergency or accident, without closing down the operations.

The main supply of compressed air is delivered through a 5-inch pipe to the quarries 1,000 feet from the power plant The quarry plant is operated solely by compressed air, and consists at the present time of two Double Drum Flory Hoisting Engines for three cable ways, and one small

hoisting engine operating a swing derrick, one duplex pump, two air drills and one small stationary engine which supplies the power for two slate sawing benches and two sets of school slate saws.

Besides the quarry operations, this plant supplies the power for the running of two slate factories, with a 30-horse power stationary engine in each one located 75 feet from the Compressor, and the other at a distance of 300 feet.—*Slate.*

Pneumatic Displacement Pump.

We give below a full description of the Pitcher and Sargent (Somerville, Mass.), Pneumatic Water Raising Device as an example of direct displacement pneumatic pump.

When water of a considerable depth is to be raised vertically upward, the "Air Lift" system furnishes a most practical means. It is, however, very often necessary to convey water, horizontally as well as vertically, to some height from shallow wells, springs and lakes by means of power generated at some distance from their sources of water supply. In such a case the Pneumatic Direct Displacement system is most practicable.

In this system air is compressed at the most convenient place, and then conducted to a displacement tank submerged in the water to be raised. This tank is provided with an air inlet and outlet and a water

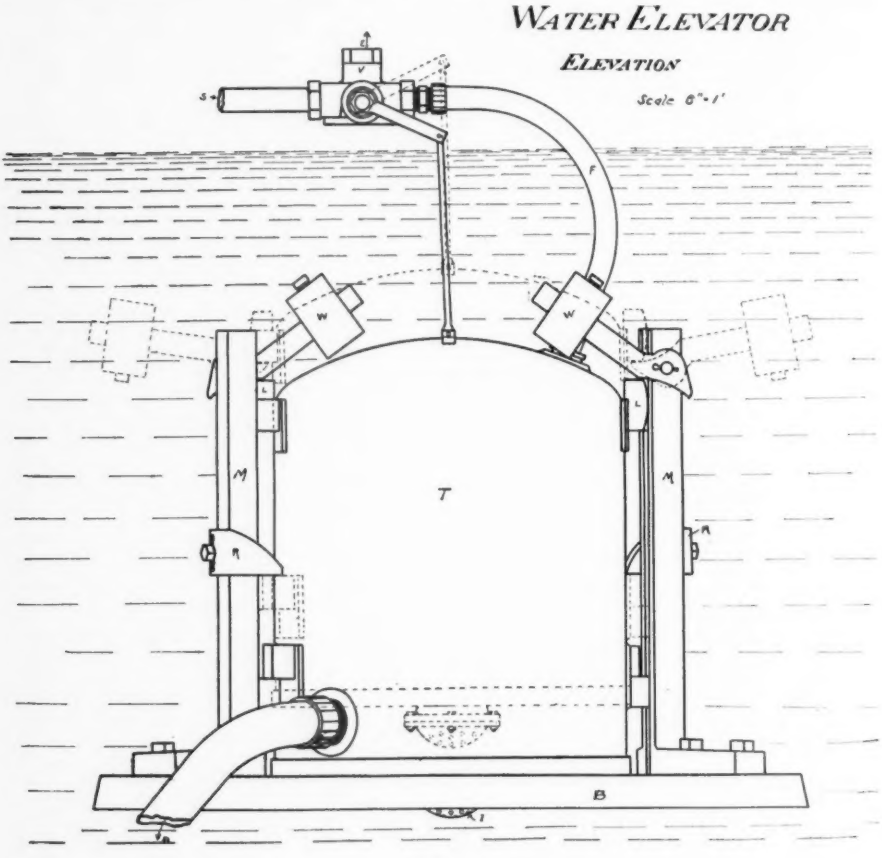


FIG. 1.

inlet and outlet. Compressed air is admitted to top of tank and displaces the water driving it out at bottom through a conducting discharge. The tank is again filled automatically with water and the operation is repeated.

The difficulty giving rise to different kinds of displacement water raising devices is in the mechanism for automatically filling the tank with water. To accomplish this, it is necessary to shut off the supply and open the exhaust for air while the tank is filling with water, and to shut the exhaust and open the supply for air when the tank has filled.

This device involves the displacement principle and overcoming the above difficulty by a simple but effectual means. The cylindrical tank T (see Fig. 1) is fitted to slide vertically in standards M, which are mounted properly on metal base. The standards bear two weighted levers W, which engage with lugs L on tank, V is an eighth turn three way valve which controls the compressed air supply and exhaust. The operation is as follows : compressed air enters at S, passes through flexible pipe F to top of tank, driving water out through flexible pipe D to reservoir. When the tank is full of air, its bouyancy overcomes the weight of levers W, it rises to dotted position, shifting the valve so that air supply is shut off, and air in tank escapes through F, to free air at E. The weighted levers now hold tank up until it has filled with water through I. When full of water the weight of tank causes it to drop to original position and process is repeated.

To work properly, the tank when submerged and full of water should weigh one-half force due to its bouyancy when full of air. The efficiency of a displacement pump is 100 p. c , when the volume of water raised is equal to the volume of air (at effectual pressure) allowed to escape. By adjusting the weights W on the levers in this device, you are able to so balance the tank that it will not fall until

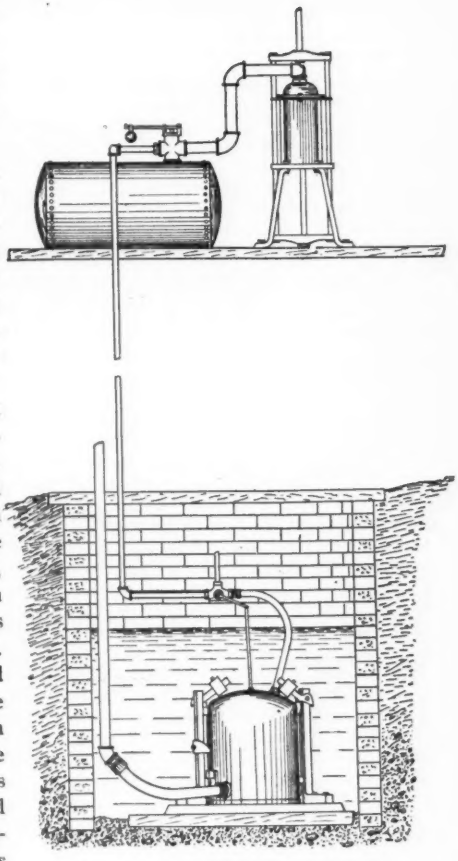


FIG. 2.

it has entirely filled with water, thus avoiding any clearance space in top of tank to be filled with air before the water can be forced out. In fact, the tank fills so quickly that the water rushes up the pipe F and out the exhaust E (provided the valve is near the surface of water) before the inertia of the tank and weights is overcome and the tank falls. Under this condition, and disregarding leakage, loss of power is minimnm.

Fig. 2 shows also the air compressor used with windmills, the plunger working from under side and attached directly to

pumping rod of mill by side rods and cross heads.

Hydraulic Plant for Compressing Air.

[CONTINUED].

In a great variety of cases, where with a low efficiency it is not worth while to use compressed air, or where electrical transmission, for instance, may be obviously preferable to transmission by compressed air, the case is entirely reversed if anything like an efficiency of 80 per cent. can be attained and attained in machines of simpler and less costly description than that which they supersede. Experience with this engine has revealed still further possibilities of improvement. Finality has not been reached, and the author does not say that an efficiency of 80 per cent. can be bettered but in other directions, such as making an engine of the same size do more work, this engine will be improved on in subsequent engines, and other developments of the same principle have also been suggested by it which are not yet carried out in practice.

In the discussion following the reading of the paper,

Mr. W. J. Jenkins said the great drawback in connection with the compression of air by direct water-power was that which caused the compressors at the Mount Cenis tunnel to be thrown out—the very large expense in laying down plant, and the very small output obtainable from it. The total cost of two of the machines at Mount Cenis was £7,000, and the amount of air turned out about 8,000 cubic feet per hour in each, or an expenditure of £3,500 for 8,000 cubic feet turned out. That amount of air could be very well compressed by a steam engine costing not more than £400. He would like to know how Mr. Pearsall measured the amount of compressed air delivered, because on that point the question of efficiency depended. He had never been able to convince himself that any system will measure compressed air properly, except by pumping it into the receiver at a certain pressure. The great drawback to any hydraulic system of direct compression would, of course, be the immense weight of the water that must be dealt with. No doubt in the colonies and other places where large water-power was obtainable, the author's apparatus would meet with considerable success.

Mr. Constantine said he knew a case where there was a large compressing plant used for mine purposes, for driving rock-drills and hydraulic motors, and the engineer was often called to account by the mining captain for not keeping up the supply of compressed air, although the engineer held that his plant was working satisfactorily. What was wanted then, was some apparatus which could be fitted to the outflow pipe leading down the mine, to register, even if only approximately, the quantity of air which had passed from the compressor to the mine. Was there any apparatus for such a purpose?

Mr. Alfred Saxon asked the author in what direction was it likely that his apparatus for compressing air would be used--in places where there was the necessary water power—instead of the other forms of power application that were available, such as electricity, steam engines, and other kinds of motive power.

Mr. Pearsall, in replying, said the Sommeiller machine at Mount Cenis only made three strokes per minute, and the reason why there was so little work done was that between each stroke it had to make a long pause. In measuring the air he had often pumped it into a spare air-vessel in a simple way which gave the exact quantity of air compressed. Perhaps the best way was to fill a second air-vessel with water, and at a given instant turn the air into it, and open a tap at the bottom so that the air coming in drove the water out; the pressure in the second air-vessel was thus kept constant, and the measure of the air pumped in was simply the measure of the water that came out. In the case mentioned by Mr. Constantine, of course if they could conveniently establish a receiver for measuring the air, it was the very best plan, but this might be a little troublesome, and in such a case it might be better to be able to ascertain at any moment how much air was passing. He did not see why they should not put a little meter on the pipe which would tell the quantity passing at any moment. Of course, the field for hydraulic plant was much greater in countries where they had larger water power than in England. With regard to compressed air compared with electricity, his idea was that in a great number of cases, if the initial cost of compressing air, which had hitherto been so great, could be very largely reduced, the economy of transmitting power by compressed air would be greater than the economy of transmitting it by electricity. There were numerous incidental advantages in compressed air as compared

with electricity. In mining, the advantages of compressed air hardly admitted of question.

The President proposed, and Mr. Ashbury seconded, a vote of thanks to Mr. Pearsall.

The American Air Power Co. of New York which combines the interests of the American Air Power Co. and the Hoadley-Knight Co., will within a short time equip the cross-town lines on 28th and 29th Streets, New York, with compressed air motors. The power-house will be at the foot of 23rd Street, opposite the Pennsylvania Railroad ferry.

This is the first permanent installation of compressed air for street car service that has ever been made in this country. Experiments and practical tests have long since demonstrated the efficiency of compressed air and the intention to have these lines working within four months does not carry with it any doubts or anxieties as to its success.

It is understood that the Hoadley-Knight system will be employed in this case, although the above Company also control the patents of the Hardie, Judson aud other motors.

From the beginning it has been a stiff up-hill fight to introduce compressed air, but the termination of obtaining a contract for such important lines of the Metropolitan Street Railway will very likely arrest the progress of other systems nntil the public have had another opportunity of trying it.

COMMUNICATIONS.

Under this heading will be published inquiries addressed to the Editor of COMPRESSED AIR. We wish to encourage our readers in the practice of making inquiries and expressing opinions.

We request that the rules governing such correspondence will be observed, viz: all communications should be written on one side of the paper only: they should be short and to the point.

March 9, 1898.

EDITOR COMPRESSED AIR:

In reading "COMPRESSED AIR" I have been much interested in the re-heating of air after it has been compressed to 80 lbs. or more; by different methods, particularly in the Sergeant Reheater, which seems to give such good results, the thought struck me that as electricity was used in connection with nearly every air compressing plant, and cars run by compressed air, for lighting, a reheater could be constructed by enclosing, in suitable form, coils of wire arranged to divide the incoming air into thin layers, and by the passage of electricity through the coils heating the air.

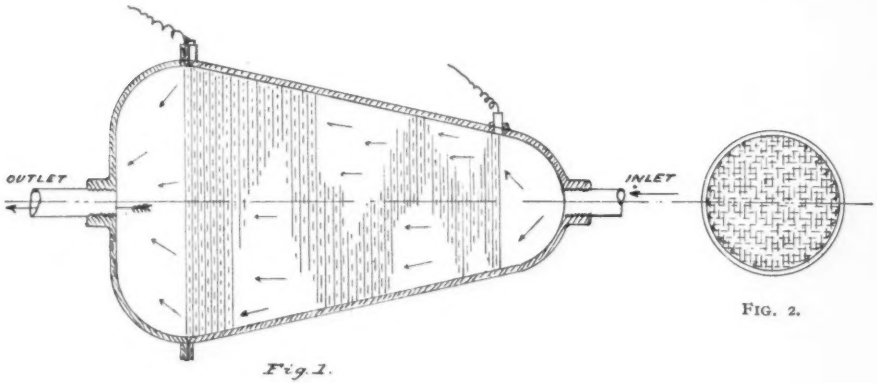


Fig. 1.

FIG. 2.

Referring to the figures above, fig. 1 is sectional view of a reheater, cone shape, the inlet being at the right, the air entering is thoroughly cut up, if I may use that expression, and becoming heated, expands and passes out at the left. Fig. 2 is an end view showing coils as they are arranged to divide the air.

WM. F. TOWEY.

21 Emery Street,
Medford Hillside, Mass.

ALPHABETICAL LIST OF INVENTIONS.

For which patents have been granted on pneumatic appliances. Prepared especially from official records for COMPRESSED AIR,

BY GRAFTON L. McGILL.

APPLIANCE.	NAME OF INVENTOR.	DATE OF ISSUE.	NO.
Compressed Air Bath	P. T. Ware	May 8, 1866	54,655
" Cylinder	G. M. Goodwyn	March 1, 1870	100,282
" Engine	D. Bickford	May 15, 1860	28,248
" "	A. M. Smith	Aug. 8, 1871	117,825
" "	W. M. Storm	Sept. 23, 1851	8,380
" "	W. C. Turnbull	April 17, 1860	27,938
" "	A. Parsey	July 31, 1847	5,205
" "	H. Bushnell	July 1, 1873	140,466
" Heater	L. Bissel	Oct. 11, 1841	2,307
" Spring	J. McNeven	Sept. 14, 1869	94,905
Fresh Air Apparatus	M. Hey	April 26, 1870	102,397
Hydraulic Air Compressor	C. Moore	July 1, 1873	140,524
" "	W. D. Leaf	June 14, 1870	104,362
" "	M. Hey	July 25, 1871	117,285
" "	W. E. Prall	Nov. 7, 1871	120,597
Method of Heating Air	A. C. Fletcher	May 19, 1863	38,637
" " "	J. Hollingsworth	June 5, 1860	28,578
Process for Mixing Air and Steam	O. M. Storm	April 5, 1853	9,654
Air Engines	Allen	July 31, 1877	193,631
"	Babcock	Jan. 12, 1886	334,152
"	"	" "	334,153
"	"	" "	334,154
"	Bair	Sept. 4, 1888	389,045
"	Baldwin	Jan. 22, 1884	292,400
"	"	June 11, 1889	404,818
"	Baldwin & Bradford	Jan. 4, 1887	355,633
"	Bolton	March 24, 1885	314,218
"	Boynton	Dec. 11, 1883	289,967
"	Bausman	May 27, 1884	299,325
"	"	March 10, 1885	313,646
"	Beaumont	Sept. 21, 1880	232,438
"	Clark	July 24, 1888	386,454
"	Close	July 12, 1887	366,204
"	Coffield	July 21, 1885	322,796
"	Colman	May 5, 1885	317,093
"	"	May 12, 1885	317,628
"	Connolly	June 22, 1875	164,809
"	Cook	Jan. 23, 1883	271,040
"	"	Feb. 20, 1883	272,656
"	Corey	Jan. 20, 1885	311,106
"	Cramer	March 4, 1884	294,369
"	Davey	Jan. 9, 1877	186,119
"	Eimecke	Jan. 2, 1883	270,036
"	Eckart	June 17, 1879	216,563
"	Ericsson	March 30, 1880	226,052

ALPHABETICAL LIST OF INVENTIONS.—*Continued.*

Appliance.	Name of Inventor.	Date of Issue	No.
Air Engines	Eteve & DeBraan	Dec. 30, 1884	309,835
"	Genty	July 31, 1888	387,063
"	Graham	July 22, 1884	302,246
"	Hanover	Jan. 6, 1885	310,419
"	Hardie & James	June 17, 1879	216,611
"	Hill	July 13, 1880	229,821
"	Hock & Martin	May 8, 1877	190,490
"	Humes	April 2, 1889	400,850
"	Hurd	Sept. 8, 1885	325,805
"	Leavitt	Oct. 28, 1884	307,312
"	"	July 14, 1885	321,985
"	Limpus	Nov. 10, 1885	329,914
"	Lochmann	Jan. 5, 1886	333,644
"	Lyman	Jan. 25, 1881	236,954
"	Matthes	April 8, 1879	214,050
"	Maxim	Feb. 5, 1884	293,185
"	Middleton	Sept. 22, 1874	155,328
"	McDonough	May 29, 1883	278,446

Patents Granted March, 1898.

Specially prepared for Compressed Air from the Patent Office files by Grafton L. McGill, Washington, D. C.

594,524 — (November, 1897) Air or Gas Compressor, Jonas Crabtree, New York, N. Y.

A pair of compressing pumps are arranged on opposite sides of, and pivotally connected to a slide-bar, the latter being reciprocated by the steam-piston. The pumps are oscillated on trunnions near their inner ends, so as to give a motion nearly coinciding with that of the slide near each end of the stroke. The inner ends of the pistons of the compressing-pumps are provided with heads abutting against and arranged to roll on each other, forming a rolling connection between said pistons that they may turn without friction. A reservoir connects with the delivery from the primary pair of cylinders and with the induction of the secondary pair by stuffing boxes maintaining tight joints and permitting of the oscillating motion. The cylinders move in unision, so that the primary pair delivers to the reservoir simultaneously with the action by the secondary pair of receiving the compressed air. Each cylinder is provided with induction and delivery valve-chambers, located in its head and containing their respective valves, the delivery-valve chamber having a cap the inner rim of which has a port establishing communication between the spaces at the rear of the delivery-valve and the delivery, and adapted to be closed by the delivery-valve when unseated. This effects the closing motion of the valve by the subsequent expansion of the air thus received.

600,258—Air Compressor. Philip Cramer, Newark, N. J., assignor one-half to C. P. W. Meeske, same place.

An air-compressing machine consists of a series of segmental sections, each of which contains a pump-cylinder and interior spaces, one of the latter communicating with the cylinders. The sections being united form the whole into an annular structure which serves as the main portion of the frame of the machine. The several interior spaces afford annular reservoirs, one for receiving compressed air from all the cylinders, and the other for the circulation of cold water for retaining a low temperature in the machine. Each section has a pair of central frame-plates provided with radial arms and a radial guide-slot in line with the adjacent pump for securing a proper movement of the piston. The pump cylinders are grouped in pairs op-

posite each other, the pistons of each pair being rigidly coupled together, while an operating cam is mounted upon a central shaft between each pair of pistons and common to all of them.

11,654 (re-issue)—Air Compressor. F. M. Graham, San Jose, Cal.

This apparatus consists of vertical water inlet and outlet pipes, the latter being of less length than the inlet. A curved joint having air-escape openings formed therein, and a water current running therethrough, unites the lower ends of the two pipes. Above this joint is located a receiver having pipe connections with the escape openings in the joint. Cups are fitted to move in the passage-way formed by the pipes and curved joint, while an elevator or conveyor receives said cups as they are discharged from the outlet pipe and delivers them to the inlet, by means of an endless carrier.

600,626—Compressor. John Stumpf, Chicago, Ill.

A fluid passage provided with a valve communicates with the piston cylinder. The valve is formed with its outer face of greater area than its inner face, so that the former is acted upon to press the valve to and from its seat under the compression and suction actions of the piston, the pressure in each instance being in the direction contrary to the movement of the piston which brings it about. This valve is located in the path of a stop movable with the piston, thus effecting the closing of the valve in the movement of the piston to the end of its traverse. The outer side of the valve being in open communication with the cylinder, presents its greater area to pressure. Thus when the valve is closed it is held so by pressure under action of the piston.

601,031—Hot-Air Compressor. Anderson & Ericksson, Chicago, Ill.

An air cylinder has a displacer-piston located therein. A second cylinder is located on, and communicates with the upper part of the air-cylinder and is provided with ports for the supply and discharge of air. A hollow working piston is located in said second cylinder and communicates with the displacer-piston. The hollow piston has ports admitting of the passage of air from the air cylinder to its hollow, and through the discharge and supply ports.

601,253—Air Brake. W. O. Gunckel, Terre Haute, Ind.

The valve casing is provided at one end with a port constantly connecting it with an air reservoir, and small ports connecting it with the supply pipe and with the brake cylinder. Two large ports in the middle of said casing also connect it with said supply and cylinder. A piston valve connects the small ports when partially raised and is provided with two spaces, of which one connects the brake cylinder with an exhaust port when the valve is lowered, and the other connects the large ports when the valve is fully raised.

601,252—Air Brake Valve. W. O. Gunckel, Terre Haute, Ind.

A valve casing is provided with an air supply connection at one end, a relief pipe connection at the other end, an exhaust passage at its middle part, and a liner provided with separate inlet and exhaust ports. A passage located behind the liner constantly connects these ports with the brake cylinder. The valve comprises two pistons of different diameters rigidly connected together and having an air space between them. The valve operates to place the brake cylinder alternately in communication with the air supply and with the atmosphere through said inlet and exhaust ports respectively.

599,907—Pneumatic Hub. W. A. Koneman, London, Eng.

This device consists of a rigid central portion, surrounding which is a resilient core, while an inflatable chamber surrounds said core. A rigid ring encircles the chamber and is provided with an internal annular projection which circumferentially indents the exterior surface of the wall of the chamber.

599,702—Pneumatic Distributing System for Liquids. Florence M. Griswold, Brooklyn, N. Y.

This invention relates particularly to storing and supplying inflammable liquids by fluid-pressure, and consists in maintaining the necessary distributing pressure upon the liquid continuously, and, upon stopping the flow of liquid, putting a pressure upon that in the tributaries opposed to the maintaining pressure and sufficient to return to the tank the liquid in said tributaries.

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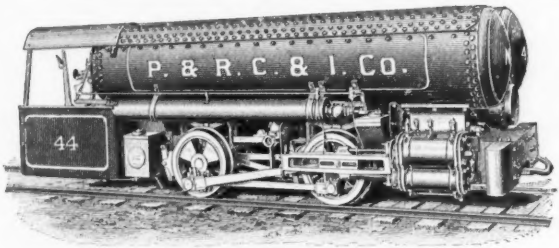

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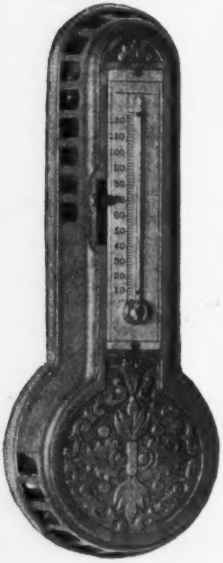

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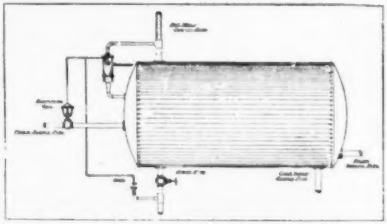

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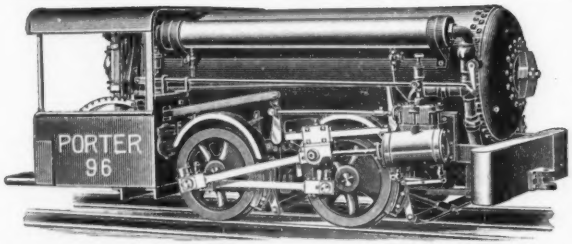

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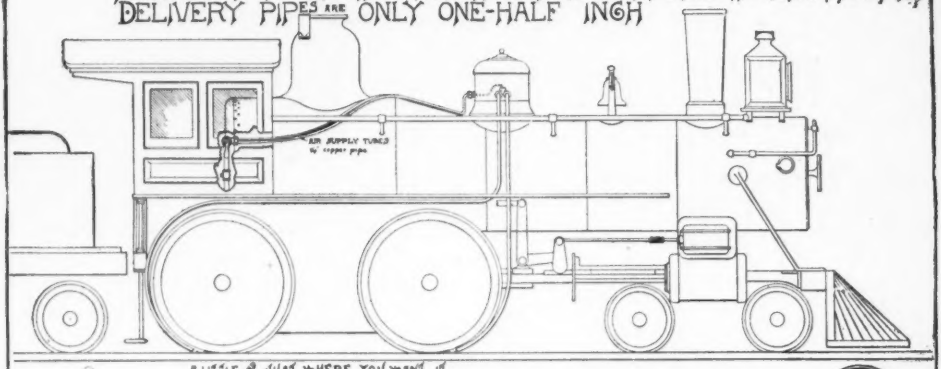

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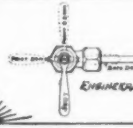
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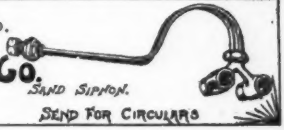
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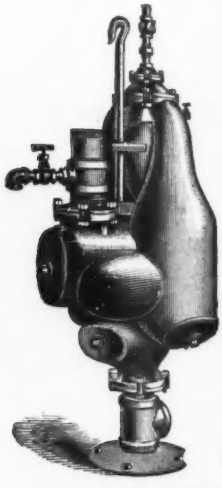

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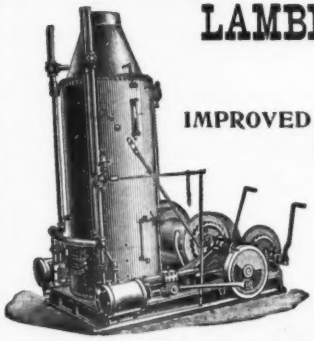

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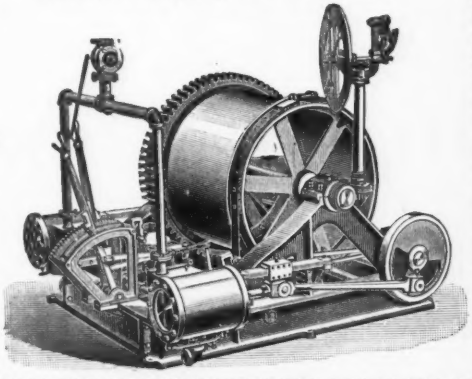

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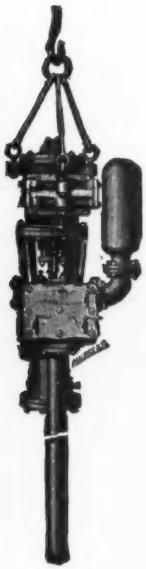

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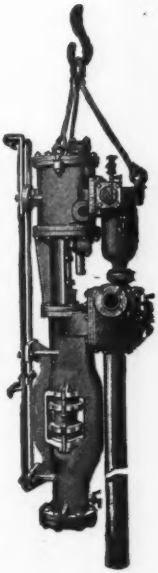

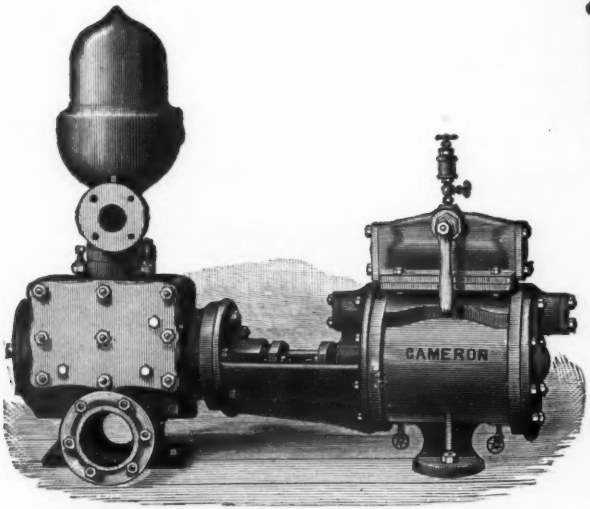

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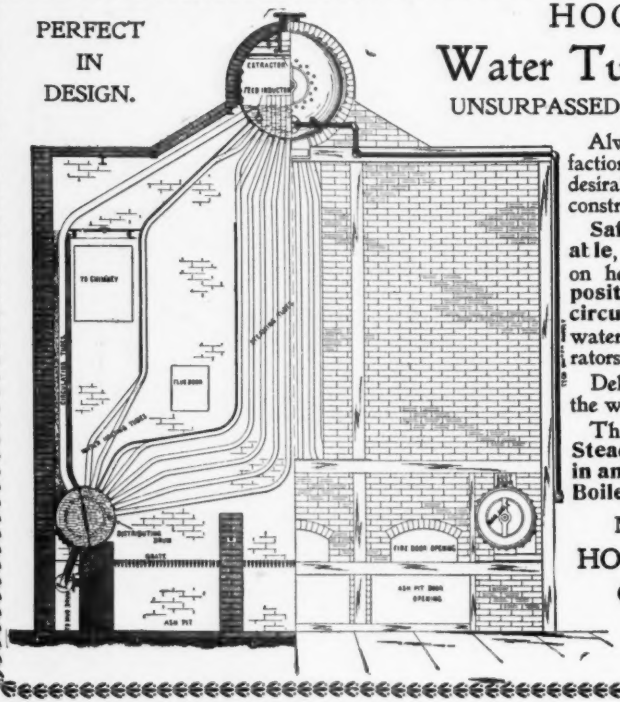

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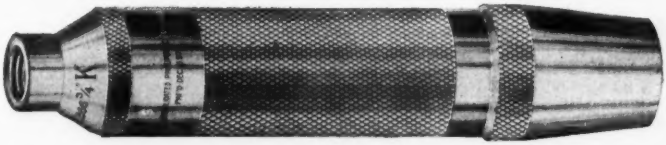

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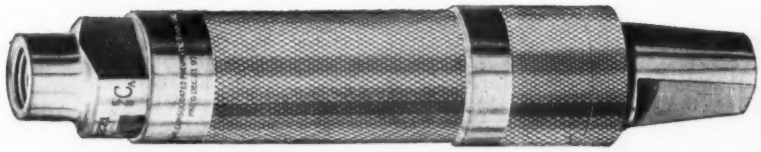

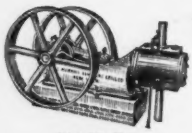

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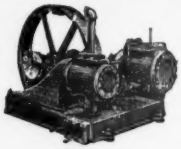

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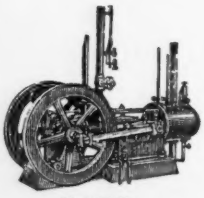

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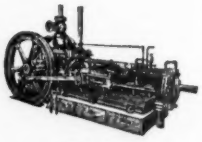

CLASS A.

COMPRESSED AIR is used for Operating Rock Drills, Coal Cutters, Pumps, Hoisting Engines and other machinery in mines and tunnels, Air Brakes on Railroad and Street Cars, Switches and Signals, Engines, Hoists, Cranes, Stone Carving and Boiler Calking Tools, Polishing Machines, Riveters, Punches, Hammers, Tapping, Screwing and Drilling Machines, Stay-bolt Cutters, Angle Iron Shears, Wood Bundling Machines and Shop Tools of every description, Oil Fires under Ovens, Furnaces and Boilers and in fifty other applications such as Welding, Annealing, Tempering, Oil Illuminating Lights, Pneumatic Transmission Tubes, Street Railway Motors and Mine Locomotives, Passenger and Freight Elevators, Sheep Shearing Machines and Cloth Cutters, Sand Blast Machines, Pneumatic Gun Carriages, Clocks, Railway Crossing Gates, Automatic Signals, Jacking-up Cars and Steering Gear of Vessels.

Charging Pneumatic Dynamite Guns and Projectiles, Automatic Sprinkler systems for fire protection, inflating Pneumatic Tires and compressing Cotton into Bales.

Tunnel Driving by the Pneumatic Process; Sinking Caissons for Structural Foundations: Pumping Wells by Air Lift Pump method: Conveying and Elevating Acids, Chemicals and other Liquids; Racking off Beer in Breweries; Aerating Water Supplies of Cities, Towns and Villages; Agitating Fluids, such as Asphalt, Lard, Molasses and Chemical Solutions; Mixing Nitro-glycerine; Removing Hose from Mandrels in rubber factories; Testing Tinware, Pipe, Hose, and other manufactured products required to stand pressure; Increasing and Maintaining pressure on Hydraulic Elevators; Sprays of all descriptions, including Physicians', Hospitals', Sanitariums' and Baths; Spraying Solution in the manufacture of silk ribbon; Moving and Elevating Grain, Culm and other material; Cleaning Carpets, Car Cushions, etc.; Unloading Dump Cars; Raising Sunken Vessels; Supplying Divers in Sub-marine Operations; Refrigerating, Ventilating and Cold Storage; Manufacture of various Gases; Disposition of Sewage; and for a large number of other duties in Railroad Shops, Chemical Works and in connection with a wide variety of Experiments and Patented Processes.

We can furnish special types of Air Compressors for every purpose to which compressed air is applied. In writing for proposal, state duty, volume (cubic feet of free air required per minute), and working air pressure desired. Also, state whether a steam, belt or gear actuated compressor is preferred. If to operate by steam direct, state steam pressure available at compressor. If belt or geared, state horse power available for operating compressor.

CLAYTON AIR COMPRESSOR WORKS,

Havemeyer Building. **26 Cortlandt Street, New York.**